

CIVIL GPS SERVICE INTERFACE COMMITTEE
TIMING SUBCOMMITTEE
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REPORT FROM THE USNO
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The U.S. Naval Observatory (USNO) is located in Washington, D.C. and its mission is to determine the positions and motions of celestial bodies, the motion of the Earth, and precise time. It provides the astronomical and timing data required by the Navy and other components of the Department of Defense for navigation, precise positioning, and command and control and communications. The USNO's measure of atomic time, Coordinated Universal Time (UTC) or UTC(USNO), is based on an ensemble of approximately 35 atomic clock devices, 28 Hewlett-Packard (HP) 5071 cesium beam frequency standards and 7 hydrogen masers. The lead USNO reference system or Master Clock, is a hydrogen maser which provides the physical realization of the computed UTC(USNO). The Master Clock generates the USNO time signal to be used as a reference for various timing systems such as GPS, Two Way Satellite Time Transfer (TWSTT) and LORAN-C. The USNO timescale is adjusted for leap seconds. The USNO has an Alternate Master Clock (AMC) facility located at Falcon AFB Colorado which duplicates the USNO timing operations in Washington, D.C.

USNO GPS Operations

USNO GPS activities consist of two types of operations, the Precise Positioning Service (PPS) and the Standard Positioning Service (SPS). The primary function of the USNO PPS operations is to provide GPS with a reliable and stable reference to Coordinated Universal Time (UTC) as maintained by the USNO for synchronization. (See CGSIC 29th Meeting Summary Report.) This is accomplished using GPS PPS timing receivers with a UTC(USNO) reference input. The USNO monitors GPS Time and UTC as transmitted from GPS, UTC(GPS), for each healthy satellite. The GPS Time correction with respect to UTC(USNO) is determined and provided to the GPS Master Control Station (MCS) on a daily basis.

As stated in ICD-GPS-200 and ICD-GPS-202, GPS Time is not to deviate from UTC(USNO) by more than one microsecond (1000 nanoseconds) and is steered at the rate $\pm 1.0 \times 10^{-19}$ seconds per second squared or 750 picoseconds per day. GPS Time has consistently remained well within the one microsecond specification and for the past year has not exceeded ± 10 nanoseconds of UTC(USNO). As a result, for the past year the time transfer RMS for UTC(GPS) was an impressive 7.18 nanoseconds which is well within the PPS specification of 56 ns (95 percent), as stated in ICD-GPS-202 (Dec 96). This is a 2 1% improvement over the previous year. The SPS specification is 340 ns (95 percent), as stated in the 1996 FRP.

The USNO SPS operations consist of various functions including common view time transfer and time steering of remote clocks. The GPS common view time transfer technique is primarily used to incorporate USNO clocks into the computation of International Atomic

Time (TAI). In addition to GPS common view time transfer, USNO has participated in GLONASS common view time transfer activities since 1993 and will participate in the International GLONASS Experiment (IGEX-98). Remote clock steering to UTC(USNO) via GPS has been accomplished at various military and civilian installations since 1986. The USNO continues to evaluate GPS Carrier Phase Time Transfer.

USNO Common View GPS with the USNO AMC

In the past, the timing community has been limited to single channel receivers. The USNO and other timing centers and laboratories have recently been testing multichannel GPS timing receivers. For the past year, the USNO has performed consistent and reliable common view time transfer with eight channel timing receivers co-located in Washington, D.C. and another located at the USNO AMC, Colorado. The common view between Washington, D.C. and Colorado averaged 400 passes per day with daily RMS values on the order of three nanoseconds. The multichannel common view precision was better than the common view using PPS single channel receivers, which averaged about 60 passes per day with daily RMS values on the order of 4.5 nanoseconds. The accuracy has been confirmed via comparisons with Two Way Satellite Time Transfer (TWSTT) and the PPS common view. The common view time transfer performed with the Washington, D.C. co-located receivers averaged 525 passes per day with daily RMS values on the order of two nanoseconds. The precision rivaled that obtained between co-located single channel receivers limited to 48 passes per day.

USNO TTR-12 Time Monitor Receiver

The USNO has recently contracted with Allen Osborne Associates (AOA) to produce a new 12-channel Time Monitor GPS Receiver (TTR-12). This will be keyed PPS receiver capable of correcting for SAAS and will track up to twelve satellite with continuous dual frequency operation. The receiver will report both code and carrier phase data and will make time comparisons with a precision of 100 picoseconds. There will be four receivers in continuous operation, two at the USNO and two at the USNO Alternate Master Clock. The receivers will be used to monitor GPS time and to provide 2SOPS with the daily UTC correction to UTC(USNO). The receivers will also be used to carry out common-view and carrier phase time transfer between the USNO Master Clock in Washington, D.C. and the USNO Alternate Master Clock in Colorado.

USNO Internet Services

The USNO also provides various Internet services including anonymous ftp, Time Service web server and Network Time Servers. Currently in operation are fourteen Network Time Protocol stratum-1 servers, providing reliable and accurate millisecond time synchronization via the Internet. Each server consists of a Hewlett-Packard industrial work station with VMEbus synchronized generators. The time servers at USNO Washington, D.C. and at the USNO AMC, Colorado, are synchronized to the local USNO Master Clocks (UTC(USNO)) to within tens of microseconds. Other USNO time servers dispersed throughout the U.S. use embedded GPS receivers providing time traceable to UTC(USNO)

via GPS. The USN0 network time servers receive more than 250 million time requests per month. In October 1997 two additional servers were set up to operate on the classified Department of Defense Internet (SIPRNET).

The USN0 Time Service Department Home Page can be accessed at
<http://tycho.usno.navy.mil>.